510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION
DECISION SUMMARY
ASSAY ONLY TEMPLATE

A. 510(k) Number:

k173403

B. Purpose for Submission:

Addition of capillary heparinized whole blood claims for pCO2, potassium, chloride, hematocrit and total hemoglobin on the GEM Premier 5000.

C. Measurand:

pCO2, potassium, chloride, hematocrit and total hemoglobin**.**

D. Type of Test:

Quantitative, potentiometric for pCO2, potassium, and chloride

Quantitative, electrical conductivity for hematocrit

Quantitative, spectrophotometric method for total hemoglobin

E. Applicant:

Instrumentation Laboratory Co.

F. Proprietary and Established Names:

GEM Premier 5000

G. Regulatory Information:

Analyte	Product Code	Classification	Regulation Section	Panel
pCO2	CHL	Class II	862.1120; Blood Gases (pCO_2, pO_2) and Blood pH system	Chemistry (75)
Potassium	CEM		862.1600; Potassium test system	
Chloride	CGZ		862.1170; Chloride test system	

Analyte	Product Code	Classification	Regulation Section	Panel
Hematocrit	GKF	Class II	862.5600; Automated hematocrit instrument	Hematology (81)
Total Hemoglobin	GKR		864.5620; Automated hemoglobin system	
	GLY		864.7500; Whole blood hemoglobin assays	

H. Intended Use:

1. Intended use(s):

   See Indications for use below

2. Indication(s) for use:

   The GEM Premier 5000 is a portable critical care system for use by health care professionals to rapidly analyze heparinized whole blood samples at the point of health care delivery in a clinical setting and in a central laboratory. The instrument provides quantitative measurements of pH, pCO_2, pO_2, sodium, potassium, chloride, ionized calcium, glucose, lactate, hematocrit, total bilirubin and CO-Oximetry (tHb, O_2Hb, COHb, MetHb, HHb, sO_2*) parameters from arterial, venous or capillary heparinized whole blood. These parameters, along with derived parameters, aid in the diagnosis of a patient's acid/base status, electrolyte and metabolite balance and oxygen delivery capacity.

   *sO_2 = ratio between the concentration of oxyhemoglobin and oxyhemoglobin plus deoxyhemoglobin.

   - pH, pCO_2, and pO_2 measurements in whole blood are used in the diagnosis and treatment of life-threatening acid-base disturbances.
   - Electrolytes in the human body have multiple roles. Nearly all metabolic processes depend on or vary with electrolytes:
   - Sodium (Na^+) measurements are used in the diagnosis and treatment of aldosteronism, diabetes insipidus, adrenal hypertension, Addison's disease, dehydration, inappropriate antidiuretic secretion, or other diseases involving electrolyte imbalance.
   - Potassium (K^+) measurements are used to monitor electrolyte balance in the diagnosis and treatment of disease conditions characterized by low or high blood potassium levels.
   - Ionized calcium (Ca^{++}) measurements are used in the diagnosis and treatment of parathyroid disease, a variety of bone diseases, chronic renal disease and tetany.
   - Chloride (Cl^-) measurements are used in the diagnosis and treatment of electrolyte and metabolic disorders, such as cystic fibrosis and diabetic acidosis.
   - Hematocrit (Hct) measurements in whole blood of the packed red cell volume of a

blood sample are used to distinguish normal from abnormal states, such as anemia and erythrocytosis (an increase in the number of red cells).

- Glucose (Glu) measurement is used in the diagnosis, monitoring and treatment of carbohydrate metabolism disturbances including diabetes mellitus, neonatal hypoglycemia, idiopathic hypoglycemia, and pancreatic islet cell carcinoma.
- Lactate (Lac) measurement is used:
  - to evaluate the acid-base status of patients suspected of having lactic acidosis;
  - to monitor tissue hypoxia and strenuous physical exertion;
  - in the diagnosis of hyperlactatemia.
- Total Bilirubin (tBili) measurement is used to aid in assessing the risk of kernicterus and hyperbilirubinemia in neonates.
- CO-Oximetry (tHb, COHb, MetHb, O_2Hb, HHb, and sO_2) evaluates the ability of the blood to carry oxygen by measuring total hemoglobin and determining the percentage of functional and dysfunctional hemoglobin species.
- Total Hemoglobin (tHb): Total hemoglobin measurements are used to measure the hemoglobin content of whole blood for the detection of anemia.
- COHb: Carboxyhemoglobin measurements are used to determine the carboxyhemoglobin content of human blood as an aid in the diagnosis of carbon monoxide poisoning.
- MetHb: Methemoglobin measurements are used to determine different conditions of methemoglobinemia.
- HHb: Deoxyhemoglobin, as a fraction of total hemoglobin, is used in combination with oxyhemoglobin to measure oxygen status.
- O_2Hb: Oxyhemoglobin, as a fraction of total hemoglobin, is used in combination with deoxyhemoglobin to measure oxygen status.
- sO_2: Oxygen saturation, more specifically the ratio between the concentration of oxyhemoglobin and oxyhemoglobin plus deoxyhemoglobin, is used to measure oxygen status.

3. Special conditions for use statement(s):

   For prescription use only at point-of-care and central laboratory settings

4. Special instrument requirements:

   GEM Premier 5000 analyzer

I. Device Description:

The GEM Premier 5000 system contains 2 key components: the GEM Premier 5000 analyzer and the GEM Premier 5000 PAK (cartridge). The GEM Premier 5000 PAK contains reagents, sensors, optical cell for Co-Ox and total bilirubin, sampler and waste bag. It enables analysis of 75 to 600 samples per cartridge. There are 5 process control solutions (A, B, C, D and E), 1 reference electrode solution and 1 lysing solution in each GEM Premier 5000 PAK. The 5 process control solutions are utilized each day at different frequencies to confirm sensor, CO-Ox and PAK performance.

The target values of the Process Control Solutions are stated in the following table:

Analyte	Units	A	B	C	D	E
K+	mmol/L	7.1	1.9	N/A	7.2	4.5
Cl-	mmol/L	49	88	N/A	141	101
pCO2	mmHg	65	33	33	25	67
Hct	(%)	28	19	N/A	26	38
tHb	(g/dL)	14.2	0	N/A	7.3	16.5

J. Substantial Equivalence Information:

1. Predicate device name(s):

   GEM Premier 4000

2. Predicate 510(k) number(s):

   k133407

3. Comparison with predicate:

Similarities		
Item	Candidate Device GEM Premier 5000 k173403	Predicate Device GEM Premier 4000 k133407
Intended Use	A portable critical care system for use by health care professionals to rapidly analyze whole blood samples at the point of health care delivery in a clinical setting and in a central laboratory.	Same
Intended User	Central Laboratory and Point-of-Care sites	Same
Sample Introduction	Aspiration	Same
PAK Shelf-Life Stability	Up to 180 days	Same
PAK Storage Temperature	15-25°C	Same
System Operating Temperature	12-32°C	Same
Calibration	2-point	Same
Reportable range pCO_2	6 to 125 mmHg	Same
Reportable range Cl^-	40 to 158 mmol/L	Same
Reportable range Hct	15 to 72%	Same
Reportable range tHb	3.0 to 23.0 g/dL	Same

Differences		
Item	Candidate Device GEM Premier 5000	Predicate Device GEM Premier 4000
Reportable range K+	1.0 to 19.0 mmol/L	0.2 to 19.0 mmol/L

K. Standard/Guidance Document Referenced (if applicable):

- CLSI EP5-A3, Evaluation of Precision Performance of Quantitative Measurement Methods; Third Edition, 2014.

- CLSI EP9-A3; Method Comparison and Bias Estimation Using Patient Samples; Approved Guideline – Third Edition, 2013

L. Test Principle:

The electrolyte sensors (K+, and Cl-) are polyvinyl chloride (PVC) based ion selective electrodes consisting of an internal Ag/AgCl reference electrode and an internal electrolyte layer. Their potentials are measured against the card reference electrode (Ag/Ag+). The electrolyte sensors are based on the principle of ion selective electrodes; in which electrical potential can be established across a membrane resulting from chemical selectivity of the membrane to a specific ion. The electrical potential is proportional to the logarithm of the analyte activity in the sample, and the concentration of the desired ions is calculated using Nernst equation.

pCO2 is measured by potentiometry using a sensor on the GEM Premier 5000 PAK. The result may be corrected for actual patient temperature if different than 37°C.

Hematocrit is measured by an electrical conductivity technique. The conductivity technique is based on the principle that because plasma is more conductive than blood cells due to the high resistance of the cell membranes, the resistivity of blood will increase as the concentration of cells increases. This relationship is expressed by the Maxwell-Fricke equation: r = Rp x (1 + Hct/100)/(1-Hct/100), where "r" is the blood resistivity, Rp is a constant based on the plasma resistivity, and Hct is hematocrit. The electrode chamber contains a miniature conductivity cell. By applying an alternating potential through the cell, the resistance of the fluid in the cell can be determined by means of Ohm's Law.

Total hemoglobin measurement is based on an optical absorbance measurement of the sample. An in-line optical cell is integrated in the flow path of the hemolyzed sample to provide a measure of hemoglobin and its derivatives. The optical cell is a flow through channel with two parallel plate optical windows separated by a well-defined path length. The chemical lysing of the sample is implemented to minimize the scattering effect of the blood and to make the spectral measurement more reliable. The optical measurement hardware, consisting of a white light-emitting diode (LED) light source, a neon reference and a high resolution spectrometer with a holographic diffraction grating and a charge-coupled device

(CCD) array, are all contained in the analyzer. Only the optical cell is located in the disposable cartridge (GEM PAK) and is aligned with the analyzer optics for spectral measurements following installation of the GEM PAK.

M. Performance Characteristics (if/when applicable):

1. Analytical performance:

a. Precision/Reproducibility:
Three separate studies were conducted to evaluate the precision of the GEM Premier 5000 system for pCO_2, K+, Cl, - Hct and tHb.

Internal Precision Studies

i. An internal precision study was performed using 5 whole blood samples with different concentrations of analytes, each run on 3 GEM Premier 5000 analyzers (a different cartridge lot was used with each instrument) for 5 days, with 1 run per day and 8 replicates measured per run per level. Samples were transferred from syringe to a capillary device prior testing. The results are summarized below:

Analyte	System Evaluator Level	N	Mean	Within Run		Between Instrument/ Lot		Total	
				SD	%CV	SD	%CV	SD	%CV
pCO2 (mmHg)	1	120	9.9	0.5	5.1	0.7	7.6%	0.9	9.1
	2	120	34.5	0.6	1.9	0.4	1.2%	0.8	2.2
	3	120	49.0	0.5	1.1	0.7	1.4%	0.9	1.8
	4	120	68.9	1.6	2.3	1.4	2.1%	2.1	3.1
	5	120	108.9	2.4	2.2	2.3	2.1%	3.3	3.0
K+ (mmol/L)	1	120	1.46	0.05	3.2	0.02	1.4%	0.05	3.5
	2	120	2.70	0.06	2.1	0.01	0.3%	0.06	2.1
	3	120	5.43	0.04	0.8	0.02	0.4%	0.05	0.9
	4	120	7.16	0.07	1.0	0.04	0.5%	0.08	1.1
	5	120	17.29	0.15	0.9	0.12	0.7%	0.20	1.1
Cl- (mmol/L)	1	120	53.4	0.4	1.0	0.1	0.2%	0.4	0.8
	2	120	75.8	0.4	0.9	0.2	0.2%	0.4	0.5
	3	120	89.8	0.4	0.8	0.1	0.1%	0.4	0.4
	4	120	110.7	0.4	0.5	0.3	0.3%	0.5	0.5
	5	120	152.8	0.7	0.4	0.6	0.4%	0.9	0.6
Hct (%)	1	120	19.3	0.6	2.9	0.2	1.0%	0.6	3.0
	2	120	32.8	0.6	1.9	0.2	0.5%	0.6	2.0
	3	120	44.7	0.6	1.3	0.3	0.6%	0.6	1.4
	4	120	55.0	0.8	1.5	0.4	0.8%	0.9	1.6
	5	120	63.7	1.3	2.0	0.9	1.4%	1.6	2.5

Analyte	System Evaluator Level	N	Mean	Within Run		Between Instrument/ Lot		Total	
				SD	%CV	SD	%CV	SD	%CV
tHb (g/dL)	1	120	7.02	0.16	2.3	0.00	0.0%	0.16	2.3
	2	120	11.06	0.09	0.8	0.03	0.3%	0.09	0.9
	3	120	14.47	0.10	0.7	0.05	0.3%	0.11	0.8
	4	120	17.34	0.09	0.5	0.02	0.1%	0.09	0.5
	5	120	19.92	0.25	1.3	0.00	0.0%	0.25	1.3

ii. Capillary Finger-stick Samples

An internal study was conducted in a Customer Simulation Laboratory (CSL) using native capillary whole blood samples. POC operators collected 2 capillary tubes per donor via finger stick puncture and tested each capillary tube in singlicate. Each sample pair was analyzed on the same GEM Premier 5000 analyzer. The results are summarized below:

Analyte	n	Mean	Within Sample Precision	
			SD	%CV
pCO2 (mmHg)	56	39	1.3	3.3
K^+ (mmol/L)	56	4.1	0.11	2.6
Cl^- (mmol/L)	56	106	0.3	0.3
Hct (%)	56	43	0.7	1.7
tHb (g/dL)	56	14.2	0.14	1.0

External precision study

iii. A precision study was performed on a GEM Premier 5000 at an external point-of-care (POC) site, using venous heparinized whole blood patient samples transferred from syringe to a capillary device and run by 3 POC operators. The study used a minimum of 20 residual whole blood samples run over 5 days. Each sample was run in triplicate. The results are summarized below:

Analyte	n	Mean	Within Sample precision	
			SD	%CV
pCO_2 (mmHg)	63	42	0.9	2.0
	3	88	0.6	0.7
K^+(mmol/L)	66	4.0	0.05	1.2
Cl^- (mmol/L)	66	107	0.5	0.5
Hct (%)	66	30	0.7	2.4
tHb (g/dL)	60	11.0	0.29	2.6

b. Linearity/assay reportable range:

Previously established in k160225, k160412, and k160415.

c. Traceability, Stability, Expected values (controls, calibrators, or methods):

As described in k160225, k160412, k160415.

d. Detection limit:

Previously established in k160225, k160412, and k160415.

e. Analytical specificity:

Previously established in k160225, k160412, and k160415.

f. Assay cut-off:

Not applicable

2. Comparison studies:

a. Method comparison with predicate device:

A method comparison study for capillary whole blood was performed at an external POC site with 6 POC operators and an internal laboratory with 3 POC operators. Two capillary samples were collected via finger-stick from each patient/donor. One sample was analyzed in singlicate on the GEM Premier 5000 (test device) and the other samples was analyzed in singlicate on the GEM Premier 4000 (predicate device). To span the reportable range for each analyte, <10% of contrived samples were prepared, transferred into capillary tubes and run in singlicate on the GEM Premier 5000 and GEM Premier 4000. The study results are shown below.

Analyte	N	Slope	Intercept	R	Sample range
pCO_2 (mmHg)	139	1.000	1.000	0.980	11 to 87
K^+ (mmol/L)	140	1.000	0.100	0.995	1.5 to 17.6
Cl^- (mmol/L)	141	1.000	-1.000	0.995	45 to 149
Hct (%)	136	1.003	-0.407	0.987	15 to 64
tHb (g/dL)	137	1.028	-0.470	0.994	4.5 to 20.5

Results based on native samples at Medical Decision Level (MDL) are shown below:

Analyte	N	Range Min	Range Max	MDL	Bias at MDL	95% CI of Bias at MDL
pCO2 (mmHg)	130	26	50	35	1.0	1.0 to 2.0
				50	1.0	1.0 to 2.0
				70	1.4%	1.4% to 3.1%
K^+ (mmol/L)	130	3.1	6.7	3.0	0.1	-0.03 to 0.19
				5.8	0.1	0.05 to 0.30
				7.5	1.3%	0.7% to 6.8%
Cl^- (mmol/L)	129	90	111	90	-1.1%	-1.1% to 0.0%
				112	-0.9%	-0.9% to 0.0%
Hct (%)	13	24	51	21	-0.4	-1.3 to 0.5
				33	-0.3	-0.7 to 0.1
				56	-0.1	-0.7 to 0.5
tHb (g/dL)	131	6.9	17.3	7.0	-0.27	-0.43 to -0.12
				10.5	-0.17	-0.25 to -0.09
				18.0	0.05	-0.07 to 0.16

b. Matrix comparison:

Not applicable. Sponsor stated that only lithium heparin whole blood is the acceptable sample type to be used for their device.

3. Clinical studies:

a. Clinical Sensitivity:

Not applicable

b. Clinical specificity:

Not applicable

c. Other clinical supportive data (when a. and b. are not applicable):

Not applicable

4. Clinical cut-off**:**

   Not applicable

5. Expected values/Reference range:

   k160225, k160412, k160415

N. Proposed Labeling:

The labeling is sufficient and it satisfies the requirements of 21 CFR Parts 801 and 809, as applicable.

O. Conclusion:

The submitted information in this premarket notification is complete and supports a substantial equivalence decision.